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Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,411,622**, on November 12, 2002, by **CATENA NETWORKS CANADA INC.**, assignee of Steven Porter, for "Silent Ringing with Reduced Device Sizes".

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Date

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Silent Ringing with reduced device sizes

1.1 Background

When DSL and POTS are sharing a telephone line, the application and removal of the POTS ringing signal can create noise. This noise requires a filter (sometimes called a POTS splitter) to prevent it from interfering with the DSL signal.

1.2 Existing Linecard Technology (Silent Ringing)

In a co-pending application, the need for a traditional POTS splitter filter is reduced by timing the removal and application of battery and ringing through feedback techniques. This approach makes the ringing transition 'silent' in the DSL band.

In order for this to operate properly, prediction and timing of the next zero crossing of the ringing signal must be taken into account by the linecard software. This implies software changes for different ringing frequencies (as used in different countries) needs to be implemented.

1.3 Existing Linecard Technology Example and Discussion

Referring to FIG. 1 there is shown a high-level block diagram illustrating a ringing controller using the technology described above.

The ringing control logic circuitry is used to connect and disconnect the two supplies (battery supply and ringing supply) from the subscriber loop at the appropriate times during the application of ringing.

Solid state switches and MOSFETs provide the actual interface to the high voltages and currents present. The solid state switches and MOSFETs are driven by signals originating in the ringing control circuitry and buffered as required.

Two MOSFET circuits are required (and wired in a back-to-back configuration) so that both positive and negative voltages with respect to ground can be controlled.

However, this approach is "make before break". That is, the battery is applied to the line before then the ring source is removed. The disconnection of the ring source from the line is timed precisely in a short interval, to within 1/20 of the period of the ring source, for the voltage crossing of the ring source and the battery. Any residual currents in the line (due to inductive elements) will flow into the battery. These currents can be quite large and require a large, low impedance device to pass these currents between the battery and the line. Although large discrete devices are available, a large device can be expensive in terms of integrated silicon area.

2 Description of the Invention

2.1 New Idea Overview

The application/removal of both the battery and the ring source are gradual, timed, and modified by a feedback network. The application of ringing can be timed relative to a particular voltage of the ring source. The removal of ringing can be timed relative to a particular voltage of the ring source, or timed to a particular ring source current, such as the zero current crossing.

A make before break approach does not have to be followed when ring source removal can be controlled gradually. When removing ringing, the ring source can be removed 'silently' over a time period comparable to half a ring cycle, before applying battery. The residual ringing line currents will decay as the ring source is removed. Then the battery is applied 'silently'. The gradual application/removal of the battery and the removal/application of the ring source may or may not overlap and may be controlled by an algorithm.

A feature of the new idea is that there would be no requirement for active (software) prediction of the next zero crossing, the circuitry can properly operate independent of the ringing frequency.

2.2 New Idea Details

In the implementation of the new idea, the various individual blocks are controlled by an algorithm. Below is a description of each of the blocks, followed by a description of the algorithm.

2.2.1.1 Ring Switch

The ring switch is composed of back-to-back FETs. This allows the 100Vrms ring signal to be controlled by a low power control signal (which drives the FETs). The control signal can be controlled to gradually increase or decrease the impedance of the switch. The bi-directional ring current requires the FETs to be back to back.

2.2.1.2 Battery Switch

The battery switch can also be composed of back to back FETs.

2.2.1.3 Feedback Network

The feedback network consists of a high pass filter. The feedback senses the signal on the line and uses feedback to modify the control signals to the Ring Switch and Battery Switch to attenuate any high frequency signals that may interfere with the DSL signal.

2.2.2 Algorithm

The algorithm can be implemented in a processor, in software, in digital hardware, in analog hardware, or in a combination thereof.

An example of the application of this idea would be on a combination POTS and xDSL linecard to minimize the impact of POTS ringing signals on xDSL signal transmission.

2.2.2.1 Algorithm for Applying Ringing

1. Wait for a trigger such as the next voltage crossing of the ring source and the battery.

2. Enable the feedback network- example is a high pass filter.

3. Hi-Z the battery switch.

4. Gradually apply the control signal over a portion of a ring cycle to turn on the ring switch.

The feedback signal is combined with the control signal to modify the transition to ringing in such a way as to attenuate any frequency content that will interfere with DSL transmission.

2.2.2.2 Algorithm for Removing Ringing

1. Wait for the ring switch current to be low, or zero current.

2. Gradually apply the control signal to turn off the ring switch over the period of roughly one fifth of a ring cycle.

The feedback signal is combined with the control signal to modify the transition from ringing in such a way as to attenuate any frequency content that will interfere with DSL transmission.

3. Gradually apply the control signal to turn on the battery switch over the period of roughly one fifth of a ring cycle.

The feedback signal is combined with the control signal to modify the transition to a battery voltage in such a way as to attenuate any frequency content that will interfere with DSL transmission.

4. Gradually apply the control signal to disable the feedback network over the period of roughly one fifth of a ring cycle.

The feedback signal is combined with the control signal to modify the transition to battery voltage in such a way as to attenuate any frequency content that will interfere with DSL transmission. During this stage, the voltages that have built up in the low-pass filter in the feedback network are discharged.

Variations are possible depending on the feedback circuit implemented.

3 Benefits

3.1 Benefits

Ringing can be applied and removed without excessive currents flowing to and from battery. This makes management of noise due to excessive current flows easier to manage in the line interface section of linecards.

A small device can be used in both FETS, which allows integration into a single IC, at lower cost with improved reliability.

There can be some thermal management benefits as well if high currents are limited / eliminated with this proposal

No software changes required for different ringing frequencies. In a similar fashion, the requirement for SW/HW interaction timing accuracy is eliminated due to the fact that the new idea does not depend on a predictive capability (of ringing zero cross).

3.2 Summary

- Use of feedback to control transition waveforms
- Gradual MOSFET turn-on control to achieve silent ringing goals
- Small devices used in a break before make configuration (instead of make before break)
- This silent ringing minimizes impact to DSL by the POTS ringing signal.

Fig. 1 - Prior Art

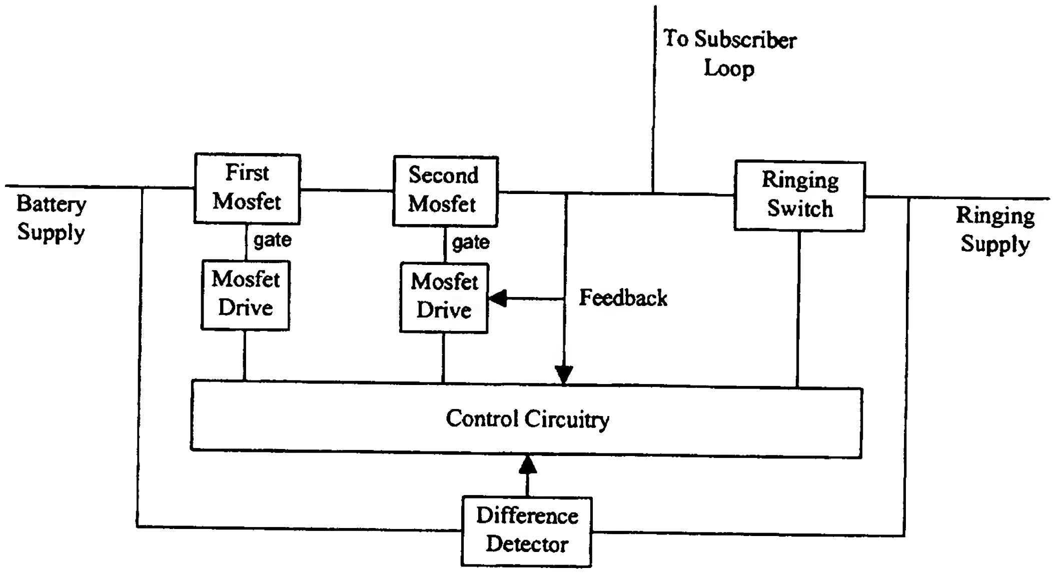

Fig. 2 New Idea Execution